# BALLISTIC RESISTANT PAD WITH METAL CORD

## Field of the invention.

The present invention relates to a ballistic resistant pad for use in protective textile or the like.

## Background of the invention.

With increasing violence in the form of terrorism, protective textiles are becoming more and more important. Protective clothing, which combines both a sufficient resistance against impacts caused by bullets and an acceptable level of comfort for the wearer, are nowadays on the market.

The required degree of impact resistance is achieved due to the relatively great plastic deformations of high-strength fibers. At the spot of the bullet burst a small crater is created in the sheet formed by the high-strength fibers. Locally the material of the high-strength fibers is contracted and shrinks. The result is that after the bullet impact, the sheet occupies a decreased surface area and, as a consequence, protects a decreased surface area. A number of consecutive bullets may result in a substantial surface area becoming unprotected by the sheet.

## Summary of the invention.

It is an object of the present invention to avoid the drawbacks of the prior art.

It is another object of the present invention to increase the degree of security of protective clothing.

It is still another object of the present invention to give adequate protection even after one or more bullet impacts.

According to the present invention, there is provided a ballistic resistant pad for use in protective textile or the like, e.g. in protective clothing. The pad comprises one or more sheets of high-strength fibers and a plurality of elongated metal elements. The elongated metal elements are attached to at least one of the sheets in a way to

give to the pad a degree of resiliency to come back close to its original form after a local impact.

The elongated metal elements may be metal wires or metal cords. Preference is given to metal cords, because of their flexibility and resulting increased comfort for the user in comparison with metal wires of the same cross-section. The metal cords are preferably steel cords.

In order to be effective the metal elements are spread over the surface of the sheet of high-strength fibers.

The elongated metal elements may be present in the ballistic resistant pad in the form of individual elongated metal elements or, preferably, may be present in the form of a fabric of woven or knitted elongated metal elements.

In order to provide the ballistic resistant pad with sufficient resiliency and integrity upon bullet impact, the elongated metal elements are preferably attached to all present sheets of high-strength fibers.

The attachment of the elongated metal elements to the sheets of high-strength fibers may be done by means of an adhesive or by means of a thermoplastic film. Preferably, however, the elongated metal elements are stitched to the sheets of high-strength fibers.

**Brief description of the drawings.**

The invention will now be described into more detail with reference to the accompanying drawings wherein

- FIGURE 1 illustrates the functioning of a prior art embodiment ;
- FIGURE 2 and FIGURE 3 illustrate each an embodiment according to the invention with individual steel cords ;

- FIGURE 4 and FIGURE 5 show each an embodiment according to the invention with steel cord fabrics.

**Description of the preferred embodiments of the invention.**

FIGURE 1 illustrates the phenomenon of a bullet impact occurring on a prior art ballistic resistant pad 10. The ballistic resistant pad 10 comprises one or more sheets 12 of synthetic high-strength fibers. A bullet creates a small crater 14. In the neighborhood of this crater the sheet material is shrinked and contracted to a degree that the sheet now has as borders 16 whereas the original borders 18 – shown in dashed lines – covered a substantially larger area. Other subsequent bullet impacts on other locations will also create craters, which will result in a further decrease of the protected surface.

FIGURE 2 shows a first embodiment of the invention. The ballistic resistant pad 20 comprises one or more sheets 22 of high-strength fibers. Useful high-strength fibers for the sheets of a ballistic-resistant pad are aramid fibers, para-aramid fibers, high-density high-molecular weight polyethylene fibers, poly(p-phenylene-2,6-benzobisoxazole) fibers (PBO fibers), polybenzimidazole fibers (PBI fibers) or any combination or mixture hereof.
Individual lengths of steel cords 24 are attached by means of stitches to the sheets 22. The steel cord lengths 24 form a particular pattern on the sheets 22 so that a large area is covered. Preferably, triangular structures are formed because of their inherent stability. Although flexible from a comfort point of view, the steel cords 24 are stiffer in compression than the high-strength synthetic fibers and give a resiliency to the sheet 22 so that this sheet 22 is able to restrain deformation in the plane and recover from a bullet impact and can come back close to its original form after a bullet impact.

FIGURE 3 shows a second embodiment of the invention. The ballistic resistant pad 20 has now another pattern of invididual lengths of steel cord 24.

The present invention is not limited to a particular type of elongated metal elements. Metal wires and metal yarns are suitable. However, because of flexibility and comfort reasons coupled with safety reasons preference is given to metal multi-strand metal cords with relatively thin filaments, i.e. filaments with a diameter ranging from 0.03 mm to 0.35 mm., e.g. from 0.05 mm to 0.32 mm.

Multi-strand metal cords are usually of the mxn-type, where m is the number of strands and n is the number of filaments within one strand. Examples of multi-strand cords are :

3x3

7x3

7x4

4x7

3 + 5x7

7x7.

Other cord types or not excluded. These other cord types may be of following general structure :

l + m (+n) : l core filaments, a layer of m filaments and, possibly a layer of n filaments

n x 1 : n filaments twisted together, n ranging from 2 to 6, hence 2 x 1, 3 x 1, 4 x 1, 5 x 1, 6 x 1 ; these n x 1 cords may be of the closed type, i.e. the cross-section has a closed configuration ; preferably, however, these n x 1 cords are of the open type, designated as OC ("open cord"), i.e. the cross-section is of the open type, i.e. not all neighboring filaments touch or contact each other

m + n : m filaments in parallel, surrounded by n filaments twisted around each other and around the m filaments

1 x n CC : compact cord with n filaments all twisted with the same twisting step in the same twisting direction.

The metal cords may be made starting from following steel composition : a carbon content higher than 0.60%, a manganese content ranging between 0.30% and 0.80%, a silicon content ranging from 0.10% to 0.40% and preferably maximum suphur and

maximum phosphorous contents of 0.03%. Lower carbon contents, e.g. below 0.40% are not excluded either.

The invention is neither limited to a particular type of coating on the metal cords. This coating can be a metal coating. However, in case the stab-resistant insert is used in a protective textile, which needs to be washed or cleaned, preference is also given to metal cords out of stainless steel or to steel cords being covered with a corrosion-resistant coating such as zinc or a zinc aluminum alloy (from 2% to 9% aluminum).
Above the metal coating, or above the steel, a synthetic coating may be provided. The synthetic coating provides some additional corrosion resistance. The presence of a synthetic coating increases the stiffness of the cord. The synthetic coating may be a polyester, a polyamide, a polyvinylchloride, and the like.
The invention is suitable for all common and available final tensile strengths from 1500 MPa to about 3500 MPa and more.

FIGURE 4 shows a third embodiment of the invention. The ballistic resistant pad 20 has one or more sheets 22 of high-strength synthetic fibers. A fabric 26 of woven steel cords 28, 30 of about the same form as the sheets 22 is stitched at various spots to the sheet 22 and provides for a complete covering of the sheet. The fabric 26 is a woven structure where both the weft 28 and the warp 30 are formed by steel cords.

FIGURE 5 shows a fourth embodiment of the invention. Here again the ballistic resistant pad 20 may have one or more sheets 22 of appropriate high-strength synthetic fibers. A first fabric 32 with steel cords 34 in warp and synthetic yarns (not shown) in weft is stitched to the sheets 22. A second fabric 36 with steel cords 38 in warp and synthetic yarns (not shown) in weft is stitched through the first fabric 32 to the sheets 22. The direction of the steel cords 34 in the first fabric 32 is different from the direction of the steel cords 38 in the second fabric 36.

If a fabric of steel cords is used instead of individual steel cord elements, the present invention is not limited to the type of fabric. In one embodiment, steel cords may form the warp whereas synthetic yarns such as aramide may form the weft. A nylon filament, such as nylon 940/2/2 binds the warp to the weft.
In a second embodiment of steel cord fabric, steel cords form the weft whereas synthetic yarns form the warp.
In a third embodiment of a steel cord fabric, steel cords both form the weft and the warp. In a first sub-embodiment, the weft and the warp run straight and are be bound together by means of a synthetic yarn. In a second sub-embodiment, the weft and the warp are interwoven and do not need an additional synthetic yarn for binding.
In a fourth embodiment of a steel cord fabric, steel cords form the weft and synthetic filaments form the warp in an alternating zigzag way : a first synthetic filament goes over and under and over the steel cords a second nylon filament goes under and over and under the steel cords, etc...

As a matter of example, a woven fabric is obtained with a 3x0.30 OC (open cord) as weft and warp and with sizes of mesh 4x4 mm or 3x3 mm. Such a woven fabric has the advantage of being light and of providing a high degree of stiffness in a direction perpendicular to the plane of the fabric.

The ballistic pad may be inserted in a cover that is impermeable to moisture. Such a cover can be made out of a fabric of GORETEX® fibers.